COTTON

Cotton. This important vegetable fibre is readily distinguished from all other commercial fibres by its spiral twist, a character that renders it especially valuable for spinning. The wide-spread distribution of the plant, its adaptability to a great variety of soils and climates, and its comparative cheapness, all tend to make it one of the great staples of agricultural production, and it is probably used by more people and for a wider range of purposes than any other fibre. The country in which cotton was first used has not been definitely determined. It had long been known in India before the conquest of that country by Alexander. The writings of Herodotus and Pliny tell us that the excellence of its fibre was known to the Greeks and Romans. Columbus found it in use by the natives of the New World and in the conquests of Mexico and Peru cotton cloth was found to be in use. Ancient Peruvian tombs have yielded mummy cloths of cotton but those obtained from Egyptian tombs appear to be linen, although it is probable that cotton was known in that country from quite early times. While the principal commercial value attaches to the beautiful fibre that surrounds the seeds, the seeds themselves have important uses aside from that of producing a new crop. The stems and roots are also of value and the so-called by-products now utilized add fully 20 per cent to the value of the commercial cotton crop.

Botany, Commercial Classification, etc.— The cotton of commerce is a product of plants of the genus *Gossypium,* a member of the *Malvaceæ* or Mallow family of plants. There have been many attempts to classify and limit the species of *Gossypium,* but no two authorities agree. In a recent widely known catalogue of plants, about 50 species are recognized, and probably four or five times as many names combined or rejected. While this list of names is quite large there are only five or six species whose product enters into commerce and the bulk of the production is the product of two species, *G. herbaceum,* which furnishes the Upland cottons, and *G. barbadense,* the source of the Sea Island cotton. All the species are of tropical origin. They are small trees, shrubs, or herbaceous plants, enduring for one, two or more years, dependent upon the species. There has been much discussion regarding the origin of the many varieties of cotton grown in this country, but by almost common consent they are all attributed to the two species mentioned above or to some of their numerous hybrids. The Sea Island cotton

is undoubtedly indigenous to America and was the type observed by Columbus, but the evidence for the American origin of the species to which the Upland cottons are referred is less conclusive. These two classes of cotton differ materially in their seed characteristics. The Sea Island has a small black seed from which the lint separates readily, while the Upland cottons have large seeds which are greenish in color and surrounded by a short dense fuzz beneath the longer and more valuable lint. Both of the species are perennial in climates without frost, but in cultivation they are treated as annuals. The plants are shrubby, 3 to 10 feet high, more or less branched and bear large, alternate 3- to 5-lobed leaves which when held to the light show numerous pellucid dots. The flowers, which resemble to a degree those of the hollyhock, mallow and hibiscus, are white when newly open in the varieties of Upland cotton, turning red with age, and a creamy yellow in the Sea Island, with a purplish spot at the base of the petals. The flowers are usually single in the axils of the leaves except in those varieties designated «cluster types» in which a number are produced together. Surrounding this conspicuous flower are three or more heart-shaped, fringed or deeply cut bracts which constitute the so-called «squares.» The indentations of the squares are deeper and more numerous in the Sea Island varieties than in the Upland forms. The capsules within the squares are the «bolls.» They are 3- to 5-celled and contain the seed covered with the white or slightly tawny lint. The bolls of Sea Island cottons are uniformly smaller and more sharply pointed, contain fewer and smaller seeds and longer lint than the Upland bolls. The lint of the Sea Island cotton is from one and one half to two and a half inches in length, while the Upland cotton of the *G. herbaceum* type seldom exceeds one and a half inches in length and much of it is shorter. There are numerous hybrids between these two types as is shown by the character of the seed and lint. The Sea Island cotton flourishes along the coast region of South Carolina, Georgia, and Florida, and also in Egypt, the famous Egyptian cotton being a development from American Sea Island cotton seed sent to Egypt a number of years ago. The varieties of Sea Island cotton furnish the finest and most valuable fibre, but their production is restricted by the soil and climatic requirements of the plants. The Upland varieties, while not furnishing so fine a quality of fibre, are grown over a much wider territory and the total production far exceeds that of the Sea Island. In India there is a perennial species to which the name *G. arboreum* is given. It is a small tree and grows about the temples, but is not cultivated to any considerable extent. It produces a fine silky staple, but its former high value is now believed to have been overrated. This cotton usually called Nurma, from its growing about temples, is also known as Deo cotton. From South America are received a number of varieties of cotton that have usually been attributed to *G. peruvianum.* They have a short, strong, curly fibre somewhat resembling wool and their smooth black seeds adhere in an oval mass, on which account they are called kidney cottons. The plant which produces this cotton is a small short-lived tree and like the Nurma cotton of India will not mature in the United States.

When considered commercially the fibre produced by the seed is the most valuable product of the cotton plant. Viewed under a good microscope it appears to be an irregular, flattened, twisted tube, the edges of which are somewhat thickened and corrugated. This twist distinguishes cotton from all other fibres and it is to this character that its superior value for spinning is due. The fibre of some of the wild species of cotton does not possess this twist and such as do not are of little value. If not thoroughly matured the fibre is more flattened, less twisted and thinner walled. Such fibres, if abundant in a sample, depreciate its value as they curl up, do not spin well nor dye evenly. Among the leading commercial types of cotton the fibre varies from ½ inch to 2 inches or more in length and is exceedingly fine, the extreme diameter measurements being 0.0084 to 0.0064 inches, the longest and finest fibre being of the Sea Island types. The commercial grading of cotton is as follows: Samples, the average fibre of which is under 0.98 inch (25 millimeters) in length are called «short staple»; those between 0.98 and 1.17 inch (25 to 30 millimeters) are called «medium» and from 1.18 to 1.57 inch (30 to 40 millimeters) are called «long staple.» Those exceeding 1.58 (40 millimeters) are «extra long.» The «long» and «extra long» fibre produced in the United States are all from Sea Island varieties and their hybrids, the shorter ones being usually Upland cottons of the *G. herbaceum* type. Other classifications adopted by the New York Cotton Exchange are: What are known as «full grades» are designated by the words «fair,» «middling fair,» «good middling,» «middling,» «low middling,» «good ordinary» and «ordinary.»

To designate qualities of staple a half grade above the grades mentioned, the prefix «strictly» is used. Quarter grades between the half grade and the next higher full grade are referred to as «barely» prefixed to the full grade term and the quarter grade below the half grade is designated by the prefix «fully» to the full grade below. As examples a staple graded as «barely middling» is a quarter grade below middling, «strict low middling» is a half grade between middling and low middling and «fully low middling» is the quarter grade between the last and low middling, a full grade. This classification is generally adopted in this country, while for Europe that of Liverpool is followed. This differs from that of the New York Exchange in being somewhat higher in the low grades and lower in the high grades. These classifications are based not only upon the length of staple, but its fineness, color, freedom from dirt, etc., and are more or less subject to differences in judgment, although little variation will be noticed in determining the quality of a sample when presented for sale.

Like every crop of wide cultivation many varieties of cotton have been produced and named. Some of these achieved a wide reputation for some superior quality, flourished for a time and then disappeared. In 1880 the Census Report named 58 well known varieties, but in less than 15 years only six were still in common cultivation. In 1896, in a publication of the United States Department of Agriculture, more than 130 varieties were described, but

within half a dozen years many of them had disappeared from seedsmen's lists. While particular varieties may cease of cultivation in a short time, the general type remains and types of cotton can now be readily recognized that have been in cultivation for more than half a century. The well-known tendency of the plant to vary is responsible for the production of so many varieties. There is perhaps no cultivated plant that responds so quickly to changed conditions of soil, climate, and cultivation as the cotton plant, and to this can be ascribed the improvement and deterioration of many varieties. The most successful planters keep up the quality of their crop by continued selection of seed and for a crop that depends so much on the quality of the staple this is one of the most important considerations. The practice of planting seed purchased from gins and mills does more to depreciate the quality of the lint than any other factor.

Cultivation.— Cotton is grown under a wide range of climatic conditions and in a great variety of soils. Ideal conditions for its growth are a deep, mellow, rich soil, a warm steamy atmosphere with abundant moisture until the bolls are well developed, with drier atmosphere and soil while the fibre is ripening and being gathered. These conditions are more nearly approximated in the cotton districts of the United States than over any other large area. Dr. Wight, who has investigated the subject for India, says for the best development of fibre an increasing daily temperature during the period of greatest growth is required and the reason for the inferiority of Indian-grown cotton from American seed, as compared with that grown in the United States, is due to the fact that in India cotton planting depends upon the monsoons and the plant develops in a constantly decreasing temperature from seeding to gathering. Too cool weather in the spring stunts the plant; too much rain during the growing season makes the plants develop at the expense of boll production, renders the soil difficult of cultivation, and promotes the growth of weeds; drought stunts the plant and causes early maturing and a small crop of inferior quality; and frosts and cold nights cause the plants to turn brown and die. If the soil is too moist it should be drained.

The method of cultivation varies somewhat in the different countries where cotton is grown, but it is believed the system practised in the United States is the most nearly perfect. The methods adopted for the cultivation of Sea Island and Upland cotton differ somewhat in detail, but in general features they are alike. In the United States bedding up the land previous to planting is almost universally practised. Where manures or chemical fertilizers are used this is indispensable if economy is practised. The beds are raised 18 inches to 2 feet in case of Sea Island and less for Upland cotton. The fertilizer and drainage thus secured make a warm seed bed in the early spring. The beds are usually arranged to stand over the furrow of the previous year in which the old stalks and trash are thrown and covered deep enough to be out of the way of the plow. The seed is generally drilled in rows 4 feet apart and when the plants attain their first true leaf and the shoots are 2 to 4 inches high, they are thinned 8 to 14 inches in the row. The date of cotton planting in the United States extends from March 1 to June 1, the most of the crop being in by May 20. The earlier date marks the beginning in southern Texas and it grows later as one goes farther northward. The young plants begin to appear in about 2 weeks and the first true leaf is gained in 8 or 10 days. After the appearance of the true leaves the plant is no longer dependent upon the seed leaves for its nourishment and is less liable to injury by cold. The first blooms appear in southern Texas about May 15, and in Tennessee and North Carolina about July 10, with intervening dates for the intermediate regions. The first bolls open after an interval of about 6 weeks from blooming and picking begins about July 10 in southern Texas, August 15 in the coast region of South Carolina and Georgia, with corresponding later dates elsewhere, and continues until after frost has killed the plants, the last picking often being made as late as December 10. For the Sea Island cotton in South Carolina and Georgia planting is usually done between April 1 and May 1, and picking begins about September 1 and continues until December. The reason for the prolonged picking season is the unequal ripening and opening of the bolls on the plant. The fields must be gone through a number of times and the ripe cotton gathered from the open bolls, or great loss will be occasioned by the shedding of the cotton. Cotton picking is the most tedious and expensive operation in cotton growing. It is mostly picked by hand into bags or baskets hung from the laborers' shoulders and all available laborers are given steady employment. The usual payment for picking cotton is from 30 to 50 cents a hundred pounds of seed cotton, expert laborers earning from $1.00 to $1.50 per day. After picking, the cotton is spread to dry and then ginned to remove the seed and baled for shipment to market.

Yield and Cost of Production.— The yield and cost of production of cotton varies widely with different localities. Differences in soil, available labor, methods of culture, etc., all exert varying influences upon the production and its profitableness. The yield of Sea Island cotton is seldom more than ⅓ bale to the acre and its cost of production is estimated at from 14 to 21 cents a pound. The yield of Upland cotton, which is by far the bulk of the crop, averaged 211 pounds per acre for the crop of 1900–1. According to Hammond the yield of lint cotton is from ⅓ to 1 bale per acre in the Pine Levels Region, ⅓ to 1¼ bales per acre in the Prairie Region of the Southern States, and ¼ to ½ bale per acre in the Table Land region. The cost of production is estimated by the same writer to average 5.88 cents per pound of lint cotton in the eastern cotton-producing States, and 5.68 cents per pound in the western States. Watkins has compiled, in 'The Cost of the Production of Cotton,' replies from 3,335 plantations representing nearly every cotton-producing county in the cotton belt, showing that the Upland cotton crop produced in 1896 cost an average of 5.27 cents per pound and sold at 6.70 cents per pound. Of those reporting, 2,659 were operated at a profit, the average cost of production being 4.90 cents per pound, and the average selling price was 6.78 cents per pound; 676 reported losses, the average cost of production being 7.62 cents per pound with the

selling price averaging 6.52 cents. These figures include all expenses of planting, cultivation, fertilizers, rents, ginning, marketing, etc., and while probably approximating the average cost of production under the present system of cotton culture in the South, can not be taken to show the minimum cost under improved methods.

Cotton Diseases and Insects.— Recent investigations have revealed the causes of a number of well-known diseases of the cotton plant. Some of these are due to disturbances in the nutrition and assimilation of the plant, others are caused by the attack of fungi, while still others are caused by the production of galls on the roots by minute worms called nematodes. Of the first class the mosaic disease or yellow leaf blight, the red leaf blight, and the shedding of bolls are the most serious. These can be remedied to a great degree by better attention to the nutrition of the plants and drainage of the soils. Experiments conducted for a number of years at the Alabama Experiment Station indicate that liberal applications of kainit as a fertilizer would greatly reduce the liability to loss from the mosaic disease. The diseases due to fungi are of a different nature. The fungi find their way into the tissues of the plant, where they live parasitically, robbing the plant of its much needed nutriment and often causing destructive changes resulting in the death of the plant. Among the more destructive diseases of this kind are: Wilt or Frenching, soreshin or damping off, anthracnose, leaf blight, and rootrot. The wilt disease is caused by the fungus *Neocosmospora vasinfecta.* This fungus lives in the soil from which it gains entrance to the cotton plant through the roots. Once in the plant the fungus develops rapidly and plugs the water-conducting vessels, cutting off the water supply of the plant and causes it to wilt suddenly. This is the most conspicuous symptom of the disease and the wilting is usually followed by the death of the plant. The fungus lives for quite a while in the soil and where abundant necessitates the abandonment of cotton growing for a time. Some varieties of cotton, especially the Egyptian ones, seem more resistant than others and where adapted should be planted to the exclusion of susceptible varieties. Cowpeas and watermelons are subject to attacks of the same or similar fungi and should not be planted in rotation upon known infected soils. Soreshin, or damping off, is due to the fungus *Pythium debaryanum,* which causes the young plant to rot off at or near the surface of the ground. Anthracnose is due to *Colletotrichum gossypii.* It attacks the stems, leaves, and bolls. It begins as small red spots which spread and darken for a time, when the centres become grayish and a pinkish color appears on the spots. These areas are usually sharply defined and give to the bolls in particular an appearance sometimes called «bird eyes.» The affected bolls either die outright or fail to open. The root rot is caused by the fungus *Ozonium auricomum* attacking the roots, causing their decay and the consequent destruction of the plant. The leaf blight due to *Sphærella gossypina,* and the mildew caused by *Ramularia areola,* attack the leaves and when abundant cause the partial or total defoliation of the plants. A bacterial disease of the bolls causes the destruction of the seed and lint within them. The nematode gall disease may readily be recognized by the presence of numerous galls upon the roots. These are caused by the widely distributed nematode, *Heterodera radicicola,* which lives in the soil and attacks the roots of a wide range of plants. Long periods of rotation and the cultivation of varieties not subject to attack are the only practical means of relief known.

Cotton is often seriously injured by insects of various kinds. Cutworms, plant lice, caterpillars, grasshoppers, stalk borers, etc., injure different parts of the plant, but the greatest damage done to the cotton crop by insects is caused by the attacks of the cotton worm or cotton caterpillar (*Aletia argillacea*), the cotton bollworm (*Heliothis armiger*), and the Mexican cottonboll weevil (*Anthonomus grandis*). See COTTON, INSECTS INJURIOUS TO; WEEVILS.

Manufacturing.— When cotton has arrived at the mill, the processes through which it must pass before being turned out as finished cloth are varied and more or less intricate. The most important step in the process of producing cloth from the raw materials is the spinning. This may be variously divided, each division embracing a group of separate manipulations. The fibre must first go through a preparatory process. The bales have their ties cut and the bagging removed when the contents of a number are thoroughly mixed to secure a more uniform product. The cotton is then run through an «opener» which cleanses the cotton from impurities, such as broken seeds, fragments of leaves and stalks, dirt, etc., and the individual fibres are thoroughly separated. It then goes to a machine that arranges the cotton into laps or rolls of an approximately uniform weight. From here it goes to the carding, combing, and drawing machines which straighten out the tangled mass, extract the very short fibres and secure the regular and uniform distribution of the fibres in parallel series. The «roving machine» draws the «sliver,» as it is called, to a more uniform size and gives it a slight twist, after which the yarn is still more attenuated and twisted in the process technically known as spinning. In some mills the process stops with the production of the yarn, while in others it goes to the loom and after various manipulations becomes the finished product. In all the processes the manipulations are rather complicated and a minute description of them should be sought under the technical topics of spinning and weaving, the process being quite similar for all fibres. Many different kinds of machines are employed, some of them of great complexity, yet so skilled do the operatives become that a single person can readily attend to the almost automatic workings of a number of the most intricate spinning mules. Just as the bale is generally considered the unit of the cotton crop, so the number of spindles and looms is taken to indicate the relative capacity of the mills manufacturing it. Great Britain leads the world in the number of its spindles, having had in 1901 over 46,000,000, followed by the continent of Europe with 32,000,000, the United States with 21,000,000, Asia (Japan, India and China) with about 7,000,000, and Canada and Mexico with 1,100,000. In the United States the greatest development in cotton manufacturing during recent years has taken place in the Southern States. Prior to the Civil War and

for a number of years following it, but a very small proportion of the cotton crop was manufactured within the States where it was produced. During this time the development of the industry in the New England and other Northern States was constant, the rate of increase being steadily maintained. In 1860 there were about 300,000 spindles and 6,700 looms in operation in the Southern States as compared with 3,900,000 spindles and 93,300 looms in New England. In 1880 the same regions reported 542,000 spindles and 11,900 looms and 8,630,000 spindles and 184,700 looms respectively. About this time the question of transportation of the raw product to the northern mills and of the finished cloth to the southern markets became important considerations and the general industrial development of the South led to the rapid growth of the cotton manufacturing in the cotton-producing States. By 1895 the number of spindles in operation in the South was nearly 2,500,000, and for the next three or four years the increase reported was nearly 400,000 per annum. In 1899 there were more than half a million more set in operation, while the increase for 1901 was over 1,200,000, making the total for the Southern States at the close of that year 5,819,835 spindles, as compared with 15,050,000 spindles for the remainder of the United States. These figures are given from Latham, Alexander & Company's Report for that year. The increase in the number of mills and looms was about the same proportion, there being a total of 531 mills and 122,902 looms in the South at the same date. According to Shepperson the mills of the United States now consume about one third of the crop produced, those of the North taking in 1901–02, 1,996,000 bales and those in the South 1,912,000 bales. While the mills in the New England States and the Southern States consume nearly the same proportion of the crop, yet the value of the products varies widely. In 1900, according to the Twelfth Census, the New England States produced from 1,829,678 bales materials valued at $191,690,913, while the Southern mills from 1,479,006 bales turned out products valued at only $95,002,059. This difference is due largely to the character of the products, the staple goods of the southern mills being those classed as brown sheetings, while the northern mills turn out a finer product at a correspondingly increased valuation. The class of goods turned out by the southern mills requires the "middling" grades of cotton which produce a relatively heavy cloth. This difference in the product of the two regions follows the general trend of all enterprises, the coarser products being first attempted, the finer ones following after a time. While some effort has been made to increase the fineness of the southern product, the profit in the cheaper grades has thus far prevented any great development along that line. There does not seem to have been much of a demand on the Sea Island cotton crop by the home mills, that cotton being exclusively used in the very finest grades of cotton weaves.

Of recent years there has been considerable interest in what are called "mercerized cottons." This process is an important adjunct to cotton manufacturing. The process consists of subjecting cotton or other vegetable fibres to the action of caustic soda dissolved in water, after which they are treated with pure water followed by dilute sulphuric acid and again washed. This treatment with chemicals causes both a physical and a chemical change in the fibre. The cotton after treatment instead of a flattened, twisted fibre, is swollen, thickened, becomes cylindrical and the cell wall is greatly thickened, with its cavity correspondingly reduced. This process, which was discovered by an Englishman, John Mercer, and patented in 1850, was designed by him to strengthen the goods and render them more uniformly subject to certain dyes. The process fell out of use to a great degree, but recently new attributes of the treated fibre were discovered. The treatment causes a decided shrinking of the goods, a fact now taken advantage of in making certain kinds of crepe cloth. It was also found that if the yarn or cloth be treated and kept under sufficient tension to prevent shrinking without being stretched, the fibre becomes translucent, and acquires a lustre similar to and but little inferior to that of silk. While apparently very simple the process is one requiring great care and skilful manipulation while the yarn is passed through the various chemical baths under heavy rollers. In practice it has been found that Sea Island and Egyptian cottons are best suited to mercerization. These fibres are already long and silky and are more uniformly acted upon. The extent of this industry is already quite important; the additional value acquired by cotton so treated in 1900 is given in the Twelfth Census Report at $697,490, more than 7,973,000 yards of cloth and 1,600,000 pounds of yarn having been mercerized.

Cotton By-products.— In the early days of cotton growing the lint was considered the only valuable product of the cotton plant. Modern ingenuity, however, has found a use for nearly every part of the plant, and if fully utilized the commercial value of the available by-products of the cotton crop reported upon in the Twelfth Census would have been more than $80,371,000, or about one fourth the total value of the crop. The cotton stalks and leaves have a considerable value as forage and if plowed under without having been burned the bare stalks aid materially in maintaining the fertility of the soil. The average yield of stalks and other refuse from an acre of cotton weigh about 850 pounds. If returned to the soil together with a portion of the seed or its equivalent in meal, the growing of cotton exhausts soil fertility very slowly, the drain on the soil of a cotton crop being less than that of any of the staple crops of the United States. The air-dried plants rank as forage with such coarse fodders as corn stover, corn shucks, rye, oat, and wheat straw, etc. It has also been proposed to extract from the stalks the strong, coarse bast fibre which they contain. If a suitable machine could be obtained for decorticating this fibre in an economical manner it could doubtless be used as bagging for the bales. A process of this kind has been patented, but it is said not to prove altogether satisfactory. A ton of stalks should yield about 300 pounds of fibre if properly extracted. In Egypt and other countries where fuel is scarce the stalks are collected and used for fuel. The bark of the root, recognized in the United States Pharmacopœa under the name *Gossypii radicis cortex,* is an active emmen-

agogue, having an action similar to that of ergot.

In computing the money value of cotton by-products none of those just mentioned are included, but only the more important products of the seed are considered. Next to the lint the most valuable commercial product of the cotton plant is its seed. As picked from the plant cotton consists approximately of ⅓ lint and ⅔ seed by weight, that is a crop of 9,000,000 bales yields about 4,500,000 tons of seed. About 7 per cent of the seed is used for planting, the remainder for oil, stock feed, fertilizer, etc. Prior to the era of cotton-seed oil mills, part of the seed was fed either raw or cooked to stock, a larger portion was plowed under as fertilizer, and the balance burned, thrown into rivers or disposed of in the easiest manner possible. The true value of the seed was not appreciated until about 25 years ago, but since 1880 the crushing of cotton seed and the extraction of the oil has become a large independent business. A ton of Upland cotton seed as it comes to the mill yields on an average 20 to 40 pounds of linters, about 1,000 pounds of meats and 890 pounds of hulls. When crushed and pressed the meats yield about 300 pounds of oil and 700 pounds of oil cake. The first process involved in reducing the seed to its products is that of removing the "linters" as the dense short fuzz is called. The yield of linters varies with the thoroughness of the ginning, sometimes amounting to 70 or 80 pounds to a ton of seed. These are removed as well as possible, for their presence would absorb considerable oil during the subsequent manipulations. Their chief use is as cotton batting. The hulls are removed next and they were formerly burned, but are now utilized as a coarse feeding stuff for cattle, and as such have a value of $2.50 to $4.00 per ton. At this rate cotton seed hulls are cheap substitutes for hay. The ashes of burned hulls have lately come into considerable demand as a fertilizer for tobacco, their value depending almost entirely on the relative abundance of potash and phosphoric acid which are present on an average of 23.40 and 9.08 per cent respectively. The cake residue from the presses, or the oil meal which is the crushed and ground cake, is extensively used both as stock food and as fertilizer. It is very rich in protein, nitrogen free extract, and fat, and can only be used to advantage as a feeding stuff when mixed with some coarser fodder. Analyses of the hulls and meal show that they supplement each other quite well as cattle feed, the hulls furnishing the necessary carbohydrates and the meal the required protein for a well-balanced ration. It was not until about 1883 that the possibility of feeding them together was definitely known, and in 1894 it was estimated that fully 400,000 cattle were fattened and 150,000 milch cows fed on rations made up very largely of cotton-seed hulls and meal. For fattening cattle, sheep, and other ruminants four pounds of hulls to one pound of meal is a successful ration, while for feeding to milch cows seven or eight pounds of hulls to one pound of meal is recommended, although an exclusive diet of this kind is not now considered advisable. In feeding cotton-seed products they should be fresh, since they appear to undergo changes after a time that render them deleterious, especially to calves and pigs. Even when fresh, for some unexplained reason, their use by young animals is attended with great danger. Cotton-seed meal is also extensively used as a fertilizer. It contains, in addition to potash and phosphoric acid, a large amount of nitrogen, and upon land that is not too dry may be compared with fish guano in its efficiency. Its value for this purpose, computed in the usual way that fertilizers are estimated, is from $20 to $25 per ton. It is an excellent fertilizer for sugar cane, corn, and cotton, and for tobacco it may be substituted for barn-yard manure.

Of the remaining constituents of the seed the oil is the most important. The report of the Twelfth Census shows there were 357 oil mills in operation which produced over 93,325,000 gallons of oil, valued at $21,390,000. The common method of oil extraction is to crush the decorticated meats and cook them in large heaters for 15 to 45 minutes, dependent upon the quantity, temperature of the vats, etc. This is one of the most important steps in extracting the oil, as too much or too little cooking diminishes the amount of oil and depreciates its quality. When in the judgment of the operator the meats are sufficiently cooked, they are folded in a camel's hair press cloth and gradually subjected to hydraulic or steam pressure that finally amounts to 3,500 pounds per square inch. Cold process oils are made, in which there is no preliminary cooking, and by some this quality of oil is preferred. When first expressed the oil is odorless, dark in color, and with a specific gravity of 0.92. This oil is then treated with alkaline solutions which precipitate the mucilaginous and albuminoid matter, together with the dark coloring matter, leaving a clear yellow oil which is drawn off, the residue being used for the manufacture of soap. With further refining this oil becomes what is technically known as "summer yellow oil." Ordinary "summer yellow oils" become cloudy at temperature of 28° to 40° F., rendering them unfit for many purposes, and "winter oils" are prepared that remain clear at 32° F. This is done by cooling the summer oils until the stearin or palmatin becomes crystallized. The hardened substances are pressed out and the remaining oil is used for salad oils, etc. "Summer yellow oil," bleached by the addition of about three per cent of fuller's earth, is changed to summer white oil, which is the basis of compound lard, cottolene, etc. "Miner's oil," which is used with kerosene as an illuminant, is made from "summer yellow oil" by treating it with sulphuric acid. In these various processes there is left considerable residue, which consists mainly of various fatty acids, and is used for making soaps. Cotton-seed oil is a slowly drying oil, on which account it is not equal to linseed oil when used with paint, although it is used to some extent in that way. It is also used as a lubricant, is employed in pharmacy, and to some degree in other arts. The coloring matter in the freshly expressed oil has also been separated, purified, and used as a dyeing material. Two important dyes have been separated, one, which is an oxydizing agent, giving a fine purple or violet blue color; the other, a non-oxidizing material called gossypin, affords a golden yellow to silk and wool.

Distribution and Production.— Cotton may be cultivated in nearly all portions of the globe between lats. 35° N. and S. or in a broad zone running around the earth and embracing the

tropics and portions of the temperate zones. Its most profitable cultivation at present is between lat. 20° and 35° N., although it is grown in Turkestan as far north as 45°. During Colonial times cotton was profitably grown in Pennsylvania, Delaware, and Maryland, and some is now grown in Kansas and Utah; however, the present limits of economic production in the United States is south of lat. 37° N. or a line running through southern Virginia, southern Kentucky, Missouri, and the northern boundary of Oklahoma. It is also grown extensively in India and Egypt, these two countries and the United States supplying fully 95 per cent of the world's crop. The estimated world's crop for 1900–01 was 13,858,000 bales, of which the United States produced 10,218,000 bales, India, including other Asiatic production, 2,390,000 bales, Egypt 1,100,000 bales, and South America 150,000 bales. For the countries other than the United States and possibly Egypt, the estimates of production do not represent the total crop, but only that portion that is marketed, and the most of it exported. India is known to have a large domestic consumption of cotton, but the amount cannot be estimated with any degree of accuracy. During the American Civil War, on account of the blockade of the southern ports, the price of cotton reached almost fabulous figures, and cotton culture was given quite a stimulus in Italy and other parts of southern Europe, as well as in Australia and elsewhere, but within less than 10 years the United States re-asserted her supremacy in cotton production and was again supplying the bulk of the requirements of the world's trade. The limiting conditions of profitable cotton growing seem to be temperature and distribution of rainfall or ability to irrigate. An average summer temperature of 73° to 75° F. and a winter temperature of 45° to 48° F. seem to furnish the proper temperature requirements, and the average distribution of rainfall of the Southern States, the moisture needed for the production of the best quality of fibre. Elevation and proximity to the sea are important factors to be considered for producing certain types of cotton, as may readily be seen in the wide variation in the quality of staple produced in contiguous regions.

The beginning of cotton culture in the United States is a matter of much speculation, but that it was carried on in a desultory way for a century or more, before becoming an important industry. seems quite probable. In some of the earlier accounts of Virginia, the writers claimed that cotton would grow in that colony as well as in any part of the world. Bancroft tells us that an experimental planting of cotton was made in Virginia in 1621, and the result was a subject of interest in America and in England. The industry spread rather slowly to the other colonies, but cotton growing had become important before the Revolutionary War in the region now known as the Cotton States. This was upland cotton. The history of the introduction and development of the culture of Sea Island cotton is better known. Sea Island cotton seed was brought from some of the West Indies, where it was indigenous, to Georgia in 1786, and it was at once found to be adapted to the coast region of that State. The following year, 1787, saw the introduction of this crop along the shores of South Carolina and Georgia, but its first recorded extensive production was in 1788, when Thomas Proctor raised 5,000 pounds upon a plantation near Savannah, Georgia, and reported it to the Philadelphia Society for the Encouragement of Manufactures.

During the early days of upland cotton-growing, the lint was separated from the seed by hand, about four pounds being considered a day's task. This slow process precluded the rapid extension of cotton production. The roller gin in use for ginning the Sea Island cotton did not differ essentially from that known in India 2,000 years before, and it was not adapted to upland cotton. In 1794 Eli Whitney patented his famous saw gin and made possible the enormous crops of later years. In estimating the cotton crop it is usual to begin the cotton year with September 1, the year being represented by figures that include portions of two calendar years, and the total yield is expressed in bales that may or may not be calculated to an uniform basis. Within 100 years, 1790 to 1890, the cotton production of the United States increased from about 5,000 bales to more than 10,000,000 bales of 400 pounds each. The cotton production of the United States by decades as given by Watkins in the United States Department of Agriculture, Division of Statistics, Miscellaneous Bulletin No. 9, was as follows:

PRODUCTION OF COTTON IN THE UNITED STATES.

Year	Crop	Net Weight of Bales
	Bales	Pounds
1790-91	8,889	225
1800-01	210,526	228
1810-11	269,360	297
1820-21	647,482	278
1830-31	1,038,847	341
1840-41	1,634,954	394
1850-51	2,454,442	416
1860-61	3,849,469	477
1870-71	4,352,317	442
1880-81	6,605,750	460
1890-91	8,652,597	473
1900-01	10,383,000	507

The largest crop produced in the United States was that of 1898–9, which was 11,275,000 commercial bales, and the smallest during the past 75 years was that of 1864–5, which was estimated at about 250,000 bales. The Sea Island crop, which is almost exclusively produced in the coast region of South Carolina, Georgia, and Florida, and on the adjacent islands, has averaged about 80,000 bales a year for the past 10 years, the crop of 1901–2 being estimated at 84,524 bales. The estimated total crop for 1902–3, according to the United States Department of Agriculture, was 10,417,000 bales of a net weight of 490.7 pounds, produced on 27,114,103 acres, or an average of 188.5 pounds of lint cotton per acre. The United States Census Bureau has been recently charged with the collection of statistics regarding the annual cotton production, and the estimate of that bureau for the crop of 1902–3 as shown by returns received from 32,753 ginneries, was 10,630,945 gross bales of 500 pounds each. The production of commercial bales by States was as follows: Alabama, 1,011,325; Arkansas, 999,629; Florida, 67,287; Georgia, 1,509,199; Indian Territory, 409,591; Kansas, 45; Kentucky, 1,308; Louisiana, 911,953; Mississippi, 1,451,626; Missouri, 49,552; North Carolina, 586,884; Oklahoma, 218,390;

South Carolina, 948,200; Tennessee, 328,019; Texas, 2,587,299; Virginia, 16,575. Of this large production about two thirds are exported, the mills of the United States only consuming about one third. While a large exporter of cotton, the United States imports considerable, taking annually about 100,000 bales of Egyptian cotton, most of which is used in the manufacture of Balbriggan underwear, hosiery, silk and cotton mixtures, and wool and cotton mixtures, etc.; and about 25,000 bales of Peruvian cotton, which is used exclusively to mix with wool to cheapen the cost of underwear, hosiery, etc.

Bibliography.— Brooks, 'Cotton and Its Uses, Varieties and Structure of Fibre'; 'The Cotton Plant,' United States Department of Agriculture, Office of Experiment Stations, Bulletin 33; Wilkinson, 'Story of the Cotton Plant'; Zipster, 'Textile Raw Materials'; Tompkins, 'Cotton and Cotton Planting'; Tompkins, 'Cotton Mill Processes'; Tompkins, 'Cotton and Cotton Oil'; Bowman, 'Structure of the Cotton Fibre'; Posselt, 'Structure of Fibres, Yarns, and Fabrics'; Ellison, 'Cotton Trade of Great Britain'; Hammond, 'The Cotton Industry'; Shepperson, 'Cotton Facts'; Latham, Alexander & Co., 'Cotton Movement and Fluctuation'; Publications of the United States Department of Agriculture, Division of Statistics and of Foreign Markets; Statistical Abstract United States Treasury Department (Washington 1903); Twelfth Census Reports.

WALTER H. EVANS,
United States Department of Agriculture.